Check List the journal of biodiversity data

LISTS OF SPECIES

Check List 11(5): 1727, 3 September 2015 doi: http://dx.doi.orsg/10.15560/11.5.1727
ISSN 1809-127X

Butterflies (Lepidoptera: Papilionoidea and Hesperioidea) from meadows of Vinogradovsky District, Arkhangelsk Region, northern European Russia, with notes on recent intense expansion of the southern species to the north

Ivan N. Bolotov[1*], **Irina A. Bochneva**[2], **Marina V. Podbolotskaya**[2†], **Mikhail Yu. Gofarov**[1, 3] and **Vitaly M. Spitsyn**[1, 2]

1 Institute of Ecological Problems of the North, the Ural Branch of the Russian Academy of Sciences, Severnaya Dvina Emb. 23, 163000 Arkhangelsk, Russian Federation
2 Department of Zoology and Ecology, Northern (Arctic) Federal University, Severnaya Dvina Emb. 17, 163002 Arkhangelsk, Russian Federation
3 Space Monitoring Centre, Northern (Arctic) Federal University, Severnaya Dvina Emb. 17, 163002 Arkhangelsk, Russian Federation
† Deceased
* Corresponding author. E-mail: inepras@yandex.ru

Abstract: The Vinogradovsky District is located at the center of the Arkhangelsk Region, one of the largest federal subjects of Northern European Russia. Boreal spruce forests are the prevalent ecosystem type in this area, but large expanses of agricultural land and herb-grass meadows are also presented there. Based on the studies of 1,699 specimens collected from three meadow sites during period 2011–2013, we provide the first data on the butterfly fauna of the district, which include 56 species, belonging to 35 genera and 5 families. Our data reveal an intense northward expansion of many southern butterfly species to the Arkhangelsk Region, including migrants (*Pontia edusa*, *Issoria lathonia*, *Vanessa atalanta* and *Vanessa cardui*) and species that have established resident populations there (*Pararge aegeria*, *Nymphalis xanthomelas*, *Aglais io*, *Lycaena dispar*, *Cupido alcetas*). Quantitative data on species diversity and phenology of butterflies are reported, including analysis of structure of butterfly assemblages and their seasonal changes.

Key words: climate warming, butterfly migration, species diversity, agricultural landscape.

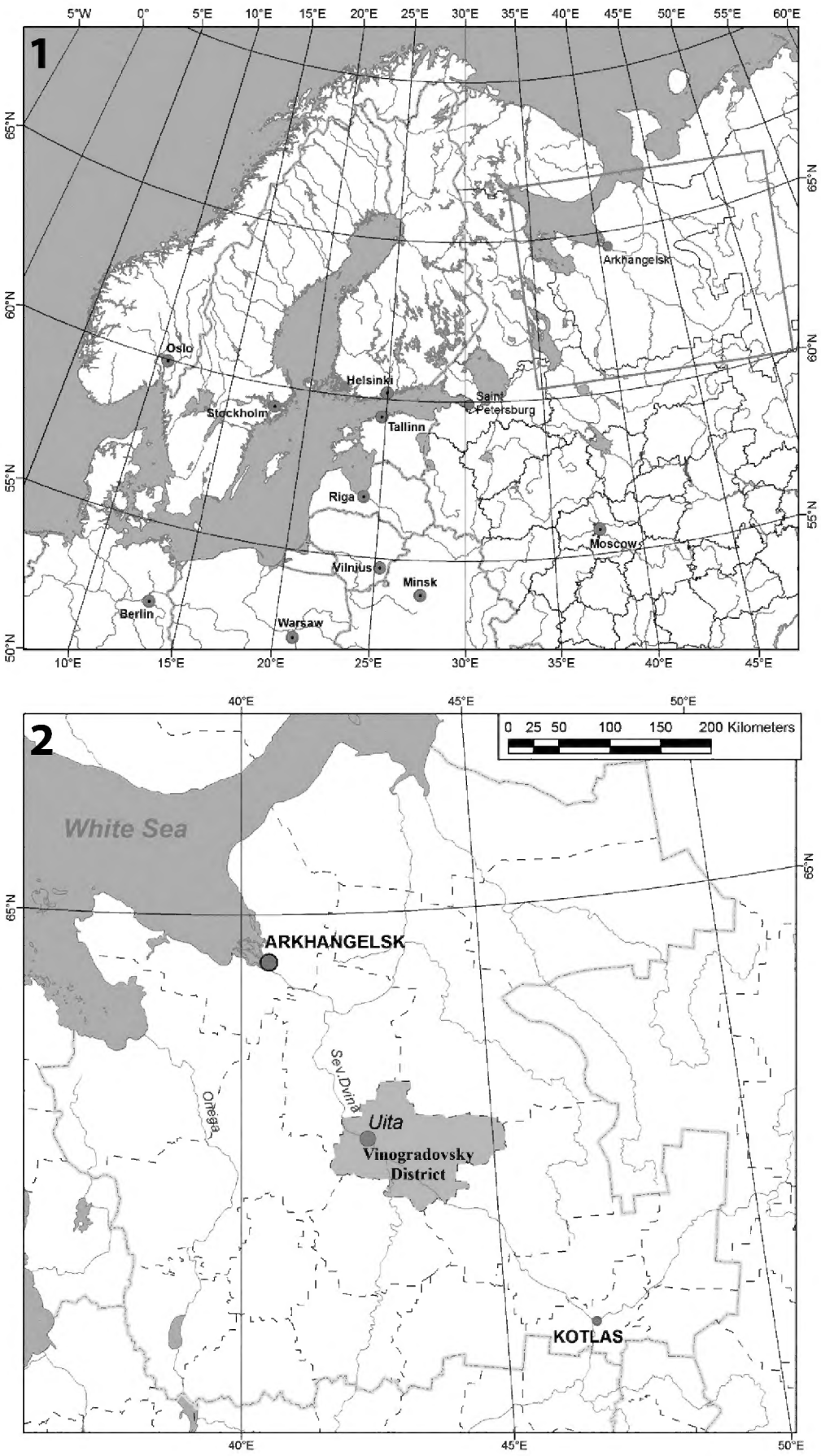
INTRODUCTION

Arkhangelsk Region is one of the largest federal subjects of the European part of the Russian Federation covering an area of 589,913 km² (together with Nenetsky Autonomous District and several High Arctic islands), which is comparable with the area of Minas Gerais State of Brazil. Boreal coniferous forest covers most of the territory, but tundra and polar desert biomes are widely distributed in the northernmost part of the region.

The fauna and diversity of butterflies of Arkhangelsk Region are relatively poorly studied. The majority of the published data (Bolotov 2006; Bolotov and Shutova 2006; Bolotov et al. 2013) reflect butterfly faunas of the islands of the White Sea, a small inland sea of the Arctic Ocean Basin. Bolotov (2012) provided a butterfly checklist for some High Arctic areas, especially Kanin Peninsula and Kolguev Island. In addition, butterfly checklists were published for Arkhangelsk city, the capital of Arkhangelsk Region (Bolotov 2002), and for Pinega State Nature Reserve (Tikhomirov and Bolotov 2000). A few studies have been carried out in Arkhangelsk Region in order to document the changes of butterfly faunas under climate warming (Bolotov 2004; Bolotov et al. 2013) and to promote the range mapping of endangered species (Bolotov et al. 2013a). The majority of those papers and a few other studies were summarised in a comprehensive review of butterfly fauna of Northern European Russia with special focus on the westernmost subjects of the country, especially Karelia Republic (Gorbach 2013).

However, there are no recent studies of butterfly faunas in the central and southern districts of the Arkhangelsk Region, including the Vinogradovsky District. The old report of Krulikovsky (1909) with some records from Kotlas, a town in the southeast of the region, contains unique data on the butterflies of this large area. In the present paper, we report the first reliable data on the fauna and diversity of butterflies

within the Vinogradovsky District, situated in the center of Arkhangelsk Region. The information is important, because of a degradation of meadow areas within the district after a general decrease of agricultural activity over the two last decades, which may negatively influence on butterfly species associated with open herb-grass habitats in the future.



Figures 1–3. Study region. **1**: Location of Arkhangelsk Region in northern Europe. **2**: Map of location of the Vinogradovsky District with Uyta Village on the Arkhangelsk Region. **3**: Herb-grass meadow near Uyta Village (collection site no. 2).

MATERIAL AND METHODS

Study area

The study area is located around Uyta village (63°00′23″ N, 042°31′08″ E; elevation 30 m above sea level [a.s.l.]) on the Severnaya Dvina River valley at the Vinogradovsky District, Arkhangelsk Region (Figures 1 and 2). The area has a temperate continental climate. Based on climate modeling data for 1901–2013 (Harris et al. 2014), average annual air temperature is 1.5°C, mean air temperature for January is –13.1°C, for July is 16.7°C. The middle-taiga spruce forests are the predominant plant communities in the area. Among the fragmented forest cover, open habitat patches are located, including willow bushes, sphagnum peat bogs and herb-grass meadows. The meadows are created after traditional agricultural practice in the area such as haying and grazing (Figure 3). The common meadow plant species are Couch Grass (*Elymus repens*), Timothy-grass (*Phleum pratense*), Meadow Fescue (*Festuca pratensis*), Red Clover (*Trifolium pratense*), Common Dandelion (*Taraxacum officinale*), Bladder Campion (*Silene vulgaris*), Fireweed (*Chamerion angustifolium*), Meadowsweet (*Filipendula ulmaria*), European Swamp Thistle (*Cirsium palustre*), and Chamomile (*Matricaria chamomilla*).

Data collection and analysis

Butterfly specimens were collected from three sites of herb-grass meadows (collector: IAB). The main method of the field studies was random collection of butterflies during sunny days using an entomological net (Bolotov 2006; Bolotov and Shutova 2006). A total of 62 samplings were carried out during the summer seasons of 2011–2013. The voucher specimens are deposited in the Department of Zoology and Ecology, Northern (Arctic) Federal University, Arkhangelsk, Russia. A few specimens are pinned and deposited in the collection of the Russian Museum of Biodiversity Hotspots (RMBH) of Institute of Ecological Problems of the North of the Ural Branch of the Russian Academy of Sciences, Arkhangelsk, Russia (INEP). Images of specimens were recorded with a digital camera (Canon EOS 450D, Canon Inc., Japan). All images were processed using Adobe Photoshop CS version 8.0. Shannon diversity indices and rarefaction richness estimations were calculated using EstimateS 9.1.0 (Colwell 2013). The species names were verified according to a recent European checklist of the butterflies (Kudrna et al. 2011).

RESULTS AND DISCUSSION

Butterfly fauna and diversity

A total of 1,699 butterfly specimens, collected on three meadow sites near Uyta village in the Vinogradovsky

District during 2011–2013, belong to 56 species from 35 genera and five families (Table 1; Figures 4, 5 and 6). For all of the surveyed sites, the most abundant species are *Aporia crataegi*, *Gonepteryx rhamni*, *Aglais urticae*, *Aphantopus hyperantus* and *Polyommatus amandus*. On separate sites, *Thymelicus lineola*, *Lasiommata maera*, *Euphydryas maturna*, *Melitaea athalia*, *Nymphalis c-album*, and *Polyommatus semiargus* are also dominant. The majority are typical common species for the agricultural regions of the European boreal zone, including the southern part of the Karelia Republic (Gorbach and Saarinen 2003; Gorbach 2013), Finland (Gorbach 2013) and Sweden (Bergman et al. 2004).

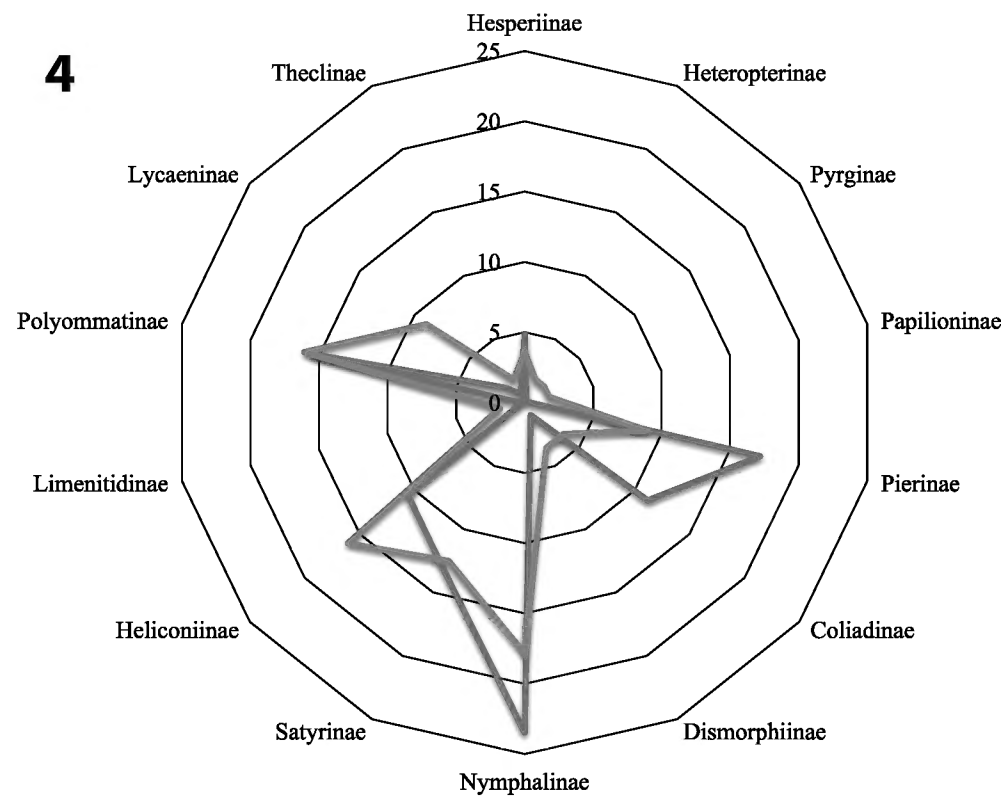
According to species composition, the butterfly assemblages on three studied sites are very similar, with 70–71% of the same species (Table 1). The number of species varied between 41 and 53 per site. Species richness is close for all of the surveyed sites (Figure 7), as well as Shannon diversity indices, which range from 2.69 to 3.15. The species diversity and richness patterns are comparable with data reported for butterfly assemblages on meadows and agricultural landscapes of the Karelia Republic (Gorbach and Saarinen 2003; Gorbach 2013) and Finland (Kuussaari et al. 2000, 2001; Heliölä et al. 2012). Structure of butterfly assemblages has significant seasonal changes, which are connected with an abundance dynamic of individual species (Figure 8). Phenology plots for common butterfly species of the study area are shown in Appendix 1.

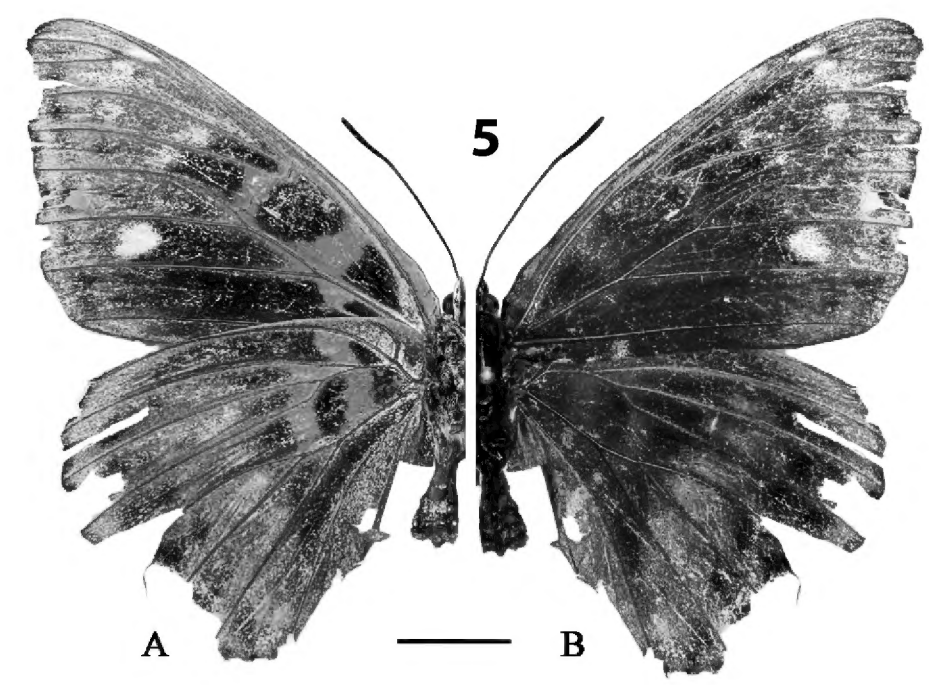
Our data reveal an intense northward expansion of many southern butterfly species to Arkhangelsk Region, including migrants (*Pontia edusa*, *Issoria lathonia*, *Vanessa atalanta*, and *Vanessa cardui*), and some species that can be established resident populations there (*Pararge aegeria*, *Nymphalis xanthomelas*, *Aglais io, Lycaena dispar*, *Cupido alcetas*). Similar patterns were documented for Finland, where many species expanded their ranges to the North in the last two decades (Saarinen 2010; Saarinen and Jantunen 2013). Those range shifts are associated with climate warming and occur throughout Europe (Parmesan et al. 1999; Warren *et al.* 2001; Bolotov 2004; Saarinen and Jantunen 2013; Gorbach 2013).

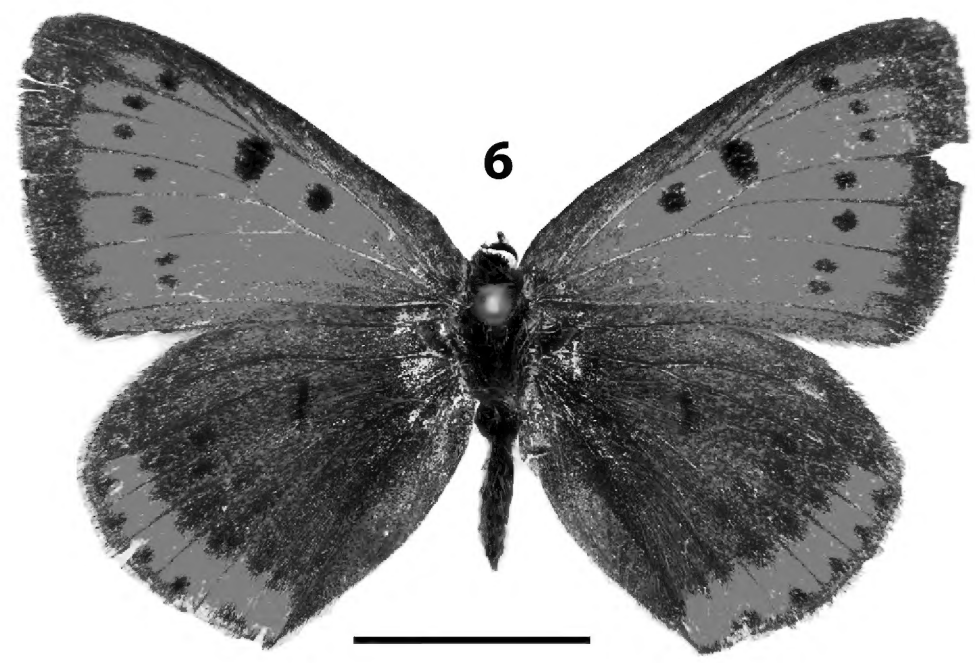
Notes on new and recent records of rare species

Pyrgus malvae (Linnaeus, 1758) (Hesperiidae: Pyrginae). Material examined: 1 specimen, 22 June 2013, site no. 3, leg. I.A. Bochneva. The species, usually, ranged up to 63° N in Northern European Russia (Gorbach 2013). First recent record from Arkhangelsk Region.

Leptidea morsei (Fenton, 1881) (Pieridae: Dismorphiinae). Material examined: 2 specimens, 16 June 2012, site no. 3, leg. I.A. Bochneva. The species is relatively rare in Arkhangelsk Region compared to the more abundant *L. sinapis* (Bol'shakov et al. 2008); rare in Komi Republic







Figures 4–6. Butterflies from the meadows of the Vinogradovsky District, Arkhangelsk Region, Northern European Russia. **4**: Taxonomic structure of the butterfly fauna (summarized data for three meadow sites, a total of 1,699 specimens from 62 samples collected in 2011–2013). **5**: Rare color form of the Poplar Admiral (*Limenitis populi* f. tremulae Esper, 1798): A – upperside, B – underside. **6**: The Large Copper (*Lycaena dispar*), a southern species, whose range recently extended northward due to climate change: upperside.

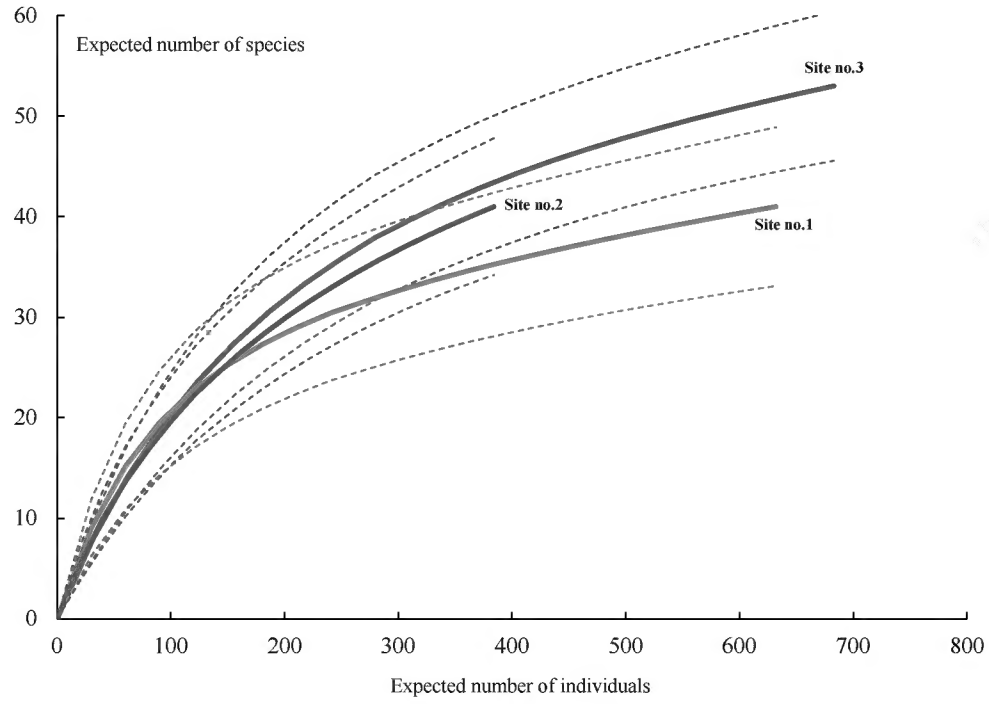


Figure 7. Rarefaction curves for butterfly assemblages from three meadows of the Vinogradovsky District, Arkhangelsk Region, Northern European Russia (a total of 1,699 specimens from 62 samples collected in 2011–2013, including site no. 1: 632 specimens in 21 samples, site no. 2: 384 specimens in 19 samples, and site no. 3: 683 specimens in 22 samples). Dashed lines are 95% confidence intervals.

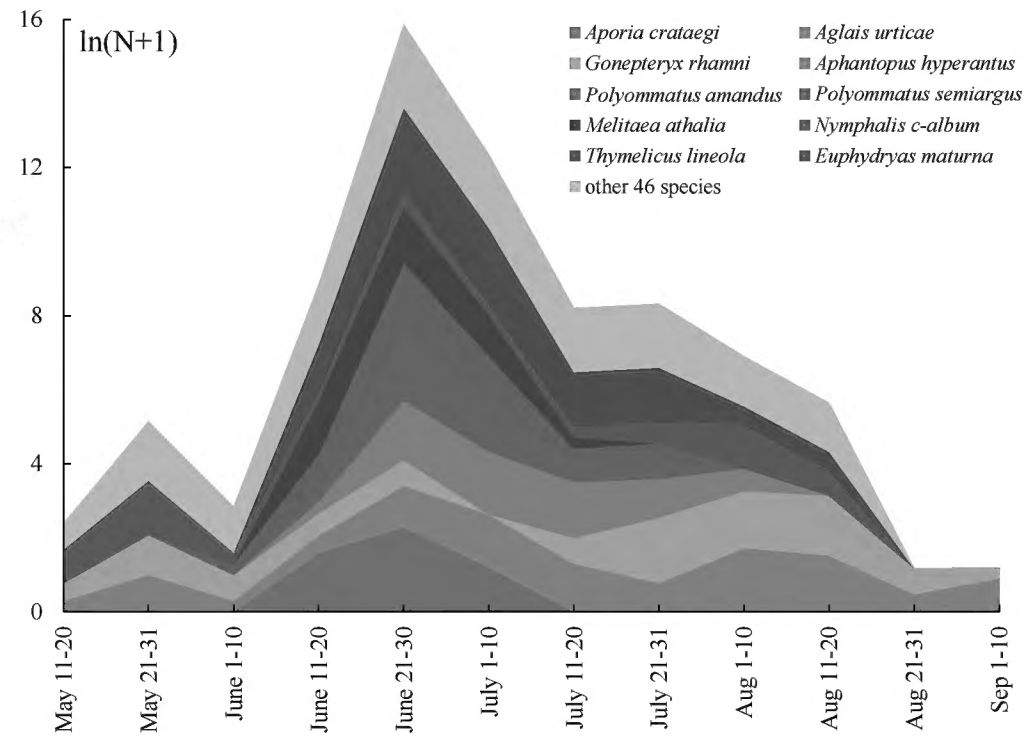


Figure 8. Seasonal change of dominant structure of butterfly assemblages (log transformed number of collected specimens) from the meadows of the Vinogradovsky District, Arkhangelsk Region, Northern European Russia. Summarized data on 1,674 specimens from 61 samples collected on three meadow sites in 2011–2013 were used (one sample was excluded from this dataset, because it was not dated precisely).

(Tatarinov and Dolgin 1999; Tatarinov 2013); not known from Karelia Republic (Gorbach 2013).

Pontia edusa (Fabricius, 1777) (Pieridae: Pierinae). Material examined: 1 specimen, 19 August 2011, site no. 3, leg. I.A. Bochneva; 2 specimens, 25 May 2012, site no. 2, leg. I.A. Bochneva. Rare vagrant species, represented in Arkhangelsk Region only by accidental migrants. Recent record of a single specimen was reported from Solovetsky Archipelago (Bolotov et al. 2013). The species is common in Komi Republic (Tatarinov and Dolgin 1999; Tatarinov 2013) and Karelia Republic (Gorbach 2013).

Erebia euryale (Esper, [1805]) (Nymphalidae: Satyrinae). Material examined: 1 specimen, 22 July 2011, site no. 1, leg. I.A. Bochneva. In Arkhangelsk Region, the species was registered as common at some localities, especially, on the White Sea-Kuloi Plateau. The species is rare in Karelia Republic (Gorbach 2013), but very abundant in Komi Republic (Tatarinov and Dolgin 1999; Tatarinov 2013).

Pararge aegeria (Linnaeus, 1758) (Nymphalidae: Satyrinae). Material examined: 1 specimen, 29 June 2013, site no. 1, leg. I.A. Bochneva. In Arkhangelsk Region, it is a rare species, with range expanding to the North within the last decade. Recent records are known from Solovetsky Archipelago and Arkhangelsk city (Bolotov et al. 2013). The species is very rare in Komi Republic (Tatarinov and Dolgin 1999; Tatarinov 2013), but relatively common in Karelia Republic (Gorbach 2013).

Boloria titania (Esper, [1793]) (Nymphalidae: Heliconiinae). Material examined: 1 specimen, 21 July 2012,

Table 1. Butterfly assemblages on meadows of Vinogradovsky District, Arkhangelsk Region, Northern European Russia (a total of 1,699 specimens in 62 samples collected in 2011–2013 from three meadow sites). N, ex. – number of collected specimens; N, % – proportion of collected specimens.

	Site no. 1		Site no. 2		Site no. 3		Total	
Taxon	**N, ex.**	**N, %**	**N, ex.**	**N, %**	**N, ex.**	**N, %**	**N, ex.**	**N, %**
Hesperiidae Latreille, 1809	33	5.2	11	2.9	44	6.4	88	5.2
Pyrginae Burmeister, 1878	–	–	–	–	1	0.1	1	0.1
Pyrgus malvae (Linnaeus, 1758)	–	–	–	–	1	0.1	1	0.1
Heteropterinae Aurivillius, 1925	2	0.3	–	–	2	0.3	4	0.2
Carterocephalus sivicola (Meigen, 1829)	2	0.3	–	–	2	0.3	4	0.2
Hesperiinae Latreille, 1809	31	4.9	11	2.9	41	6.0	83	4.9
Thymelicus lineola (Ochsenheimer, 1808)	25	4.0	5	1.3	30	4.4	60	3.5
Ochlodes sylvanus (Esper, 1777)	6	0.9	6	1.6	11	1.6	23	1.4
Papilionidae Latreille, [1802]	–	–	1	0.3	2	0.3	3	0.2
Papilioninae Latreille, [1802]	–	–	1	0.3	2	0.3	3	0.2
Papilio machaon Linnaeus, 1758	–	–	1	0.3	2	0.3	3	0.2
Pieridae Duponchel, [1835]	118	18.7	167	43.5	214	31.3	499	29.4
Dismorphiinae Shatz, 1887	–	–	–	–	17	2.5	17	1.0
Leptidea morsei (Fenton, 1881)	–	–	–	–	2	0.3	2	0.1
Leptidea sinapis (Linnaeus, 1758)	–	–	–	–	15	2.2	15	0.9

Continued

Table 1. *Continued.*

Taxon	Site no. 1		Site no. 2		Site no. 3		Total	
	N, ex.	N, %	N, ex.	N, %	N, ex.	N, %	N, ex.	N, %
Pierinae Duponchel, [1835]	52	8.2	81	21.1	159	23.3	292	17.2
Anthocharis cardamines (Linnaeus, 1758)	1	0.2	–	–	14	2.0	15	0.9
Aporia crataegi (Linnaeus, 1758)	42	6.6	77	20.1	128	18.7	247	14.5
Pieris napi (Linnaeus, 1758)	3	0.5	–	–	2	0.3	5	0.3
Pieris rapae (Linnaeus, 1758)	6	0.9	3	0.8	13	1.9	22	1.3
Pontia edusa (Fabricius, 1777)	–	–	1	0.3	2	0.3	3	0.2
Coliadinae Swainson, 1827	66	10.4	86	22.4	38	5.6	190	11.2
Colias palaeno (Linnaeus, 1761)	13	2.1	3	0.8	4	0.6	20	1.2
Gonepteryx rhamni (Linnaeus, 1758)	53	8.4	83	21.6	34	5.0	170	10.0
Nymphalidae Swainson, 1827	342	54.1	172	44.8	293	42.9	807	47.5
Satyrinae Boisduval, [1833]	119	18.8	39	10.2	67	9.8	225	13.2
Aphantopus hyperantus (Linnaeus, 1758)	67	10.6	23	6.0	43	6.3	133	7.8
Coenonympha glycerion (Borkhausen, 1788)	15	2.4	10	2.6	14	2.0	39	2.3
Erebia euryale (Esper, [1805])	1	0.2	–	–	–	–	1	0.1
Erebia ligea (Linnaeus, 1758)	11	1.7	4	1.0	1	0.1	16	0.9
Lasiommata maera (Linnaeus, 1758)	24	3.8	2	0.5	3	0.4	29	1.7
Lasiommata petropolitana (Fabricius, 1787)	–	–	–	–	6	0.9	6	0.4
Pararge aegeria (Linnaeus, 1758)	1	0.2	–	–	–	–	1	0.1
Heliconiinae Swainson, 1822	77	12.2	36	9.4	67	9.8	180	10.6
Argynnis adippe ([Denis & Schiffermüller], 1775)	2	0.3	2	0.5	11	1.6	15	0.9
Argynnis aglaja (Linnaeus, 1758)	13	2.1	2	0.5	8	1.2	23	1.4
Argynnis paphia (Linnaeus, 1758)	3	0.5	14	3.6	5	0.7	22	1.3
Boloria aquilonaris (Stichel, 1908)	23	3.6	1	0.3	3	0.4	27	1.6
Boloria euphrosyne (Linnaeus, 1758)	15	2.4	6	1.6	12	1.8	33	1.9
Boloria selene ([Denis & Schiffermüller], 1775)	12	1.9	3	0.8	15	2.2	30	1.8
Boloria titania (Esper, [1793])	1	0.2	1	0.3	2	0.3	4	0.2
Brenthis ino (Rottemburg, 1775)	7	1.1	7	1.8	10	1.5	24	1.4
Issoria lathonia (Linnaeus, 1758)	1	0.2	–	–	1	0.1	2	0.1
Limenitidinae Behr, 1864	0	0.0	2	0.5	1	0.1	3	0.2
Limenitis populi (Linnaeus, 1758)	0	0.0	2	0.5	1	0.1	3	0.2
Nymphalinae Swainson, 1827	146	23.1	95	24.7	158	23.1	399	23.5
Aglais io (Linnaeus, 1758)	0	0.0	1	0.3	2	0.3	3	0.2
Aglais urticae (Linnaeus, 1758)	59	9.3	51	13.3	68	10.0	178	10.5
Araschnia levana (Linnaeus, 1758)	4	0.6	1	0.3	5	0.7	10	0.6
Euphydryas maturna (Linnaeus, 1758)	30	4.7	8	2.1	12	1.8	50	2.9
Melitaea athalia (Rottemburg, 1775)	46	7.3	8	2.1	13	1.9	67	3.9
Nymphalis antiopa (Linnaeus, 1758)	1	0.2	2	0.5	7	1.0	10	0.6
Nymphalis c-album (Linnaeus, 1758)	3	0.5	19	4.9	46	6.7	68	4.0
Nymphalis xanthomelas (Esper, [1781])	3	0.5	3	0.8	3	0.4	9	0.5
Vanessa atalanta (Linnaeus, 1758)	–	–	1	0.3	1	0.1	2	0.1
Vanessa cardui (Linnaeus, 1758)	–	–	1	0.3	1	0.1	2	0.1
Lycaenidae [Leach], [1815]	139	22.0	33	8.6	130	19.0	302	17.8
Theclinae Swainson, 1831	1	0.2	1	0.3	9	1.3	11	0.6
Callophrys rubi (Linnaeus, 1758)	1	0.2	1	0.3	9	1.3	11	0.6
Lycaeninae [Leach], [1815]	5	0.8	4	1.0	19	2.8	28	1.6
Lycaena dispar (Haworth, 1802)	1	0.2	–	–	1	0.1	2	0.1
Lycaena helle ([Denis & Schiffermüller], 1775)	–	–	–	–	1	0.1	1	0.1
Lycaena hippothoe (Linnaeus, 1761)	2	0.3	–	–	1	0.1	3	0.2
Lycaena phlaeas (Linnaeus, 1761)	–	–	1	0.3	–	–	1	0.1
Lycaena virgaureae (Linnaeus, 1758)	2	0.3	3	0.8	16	2.3	21	1.2
Polyommatinae Swainson, 1827	133	21.0	28	7.3	102	14.9	263	15.5
Aricia eumedon (Esper, [1780])	13	2.1	1	0.3	6	0.9	20	1.2
Celastrina argiolus (Linnaeus, 1758)	–	–	–	–	3	0.4	3	0.2
Cupido alcetas (Hoffmannsegg, 1804)	–	–	1	0.3	1	0.1	2	0.1
Cupido minimus (Fuessly, 1775)	–	–	–	–	1	0.1	1	0.1
Plebejus optilete (Knoch, 1781)	3	0.5	2	0.5	1	0.1	6	0.4
Plebejus argus (Linnaeus, 1758)	1	0.2	2	0.5	1	0.1	4	0.2
Polyommatus amandus (Schneider, 1792)	80	12.7	17	4.4	28	4.1	125	7.4
Polyommatus icarus (Rottemburg, 1775)	11	1.7	1	0.3	8	1.2	20	1.2
Polyommatus semiargus (Rottemburg, 1775)	25	4.0	4	1.0	53	7.8	82	4.8

site no. 3, leg. I.A. Bochneva; 3 specimens, 8 July 2013, by one specimen from each of sites nos. 1–3, leg. I.A. Bochneva. In Arkhangelsk Region, it is a rare species with fragmentary distribution, documented within the vicinity of Arkhangelsk city (Bolotov 2002) and Pinega State Nature Reserve (Tikhomirov and Bolotov 2000). This was an abundant population of the species found within a humid tall-herb forest meadow at the White Sea-Kuloi Plateau (65°13′29″ N, 041°10′06″ E, elev. 130 m a.s.l.) in 2013. The species is relatively common in Komi Republic (Tatarinov and Dolgin 1999; Tatarinov 2013), but rare in Karelia Republic (Gorbach 2013).

Issoria lathonia (Linnaeus, 1758) (Nymphalidae: Heliconiinae). Material examined: 1 specimen, 27 May 2012, site no. 3, leg. I.A. Bochneva; 1 specimen, 21 June 2012, site no. 1, leg. I.A. Bochneva. First recent record from Arkhangelsk Region, where it is a rare vagrant species that is represented only by accidental migrants. The species is very rare in Komi Republic (Tatarinov and Dolgin 1999; Tatarinov 2013) and in Karelia Republic (Gorbach 2013).

Limenitis populi (Linnaeus, 1758) f. **tremulae** Esper, 1798 (Nymphalidae: Limenitidinae). Material examined: 1 specimen, 3 August 2012, site no. 2, leg. I.A. Bochneva (Figure 5). This melanistic form is unusual for northern populations of the species; it is a first occurrence in the Arkhangelsk Region.

Aglais io (Linnaeus, 1758) (Nymphalidae: Nymphalinae). Material examined: 1 specimen, 21 May 2012, site no. 3, leg. I.A. Bochneva; 1 specimen, 12 August 2012, site no. 3, leg. I.A. Bochneva; 1 specimen, 7 August 2013, site no. 2, leg. I.A. Bochneva. The species was rare in Arkhangelsk Region, and only a few accidental migrants in separate seasons were recorded there (Bolotov 2004), but its abundance has increased within the last few years. I.N. Bolotov recorded an overwintered specimen in Arkhangelsk city (64°31′51″ N, 040°37′35″ E, ca. 200 km northward from Uyta village) on 13 May 2014, that demonstrates its successful hibernation at 64°32′ N. The species has become common in boreal regions of Northern European Russia within the last decade (Tatarinov and Dolgin 1999; Tatarinov 2013; Gorbach 2013).

Vanessa atalanta (Linnaeus, 1758) (Nymphalidae: Nymphalinae). Material examined: 1 specimen, 29 June 2012, site no. 2, leg. I.A. Bochneva; 1 specimen, 7 August 2013, site no. 3, leg. I.A. Bochneva. In Northern Europe, it is a seasonal vagrant species, which can successfully breed here with an autumn return migration of a new generation of adults to southern regions (Stefanescu 2001; Mikkola 2003a, 2003b). The species is usually rare in Arkhangelsk Region.

Vanessa cardui (Linnaeus, 1758) (Nymphalidae: Nymphalinae). Material examined: 1 specimen, 12 June 2012, site no. 2, leg. I.A. Bochneva; 1 specimen, 7 July 2012, site no. 3, leg. I.A. Bochneva. Similar to *Vanessa atalanta*, it is a seasonal vagrant species (Stefanescu et al. 2007, 2011, 2012; Gorbach 2013). In Arkhangelsk Region, three abundant migrations of the species were observed, especially in 1996, 1998 and 2009 (Bolotov 2002, 2004; Bolotov et al. 2013), which are comparable with data reported from European countries (Marttila et al. 2001; Saarinen and Jantunen 2013; Stefanescu et al. 2011, 2012). Since the most impressive migration of 2009, the species was occasionally recorded in Arkhangelsk Region, with a low number of individuals.

Nymphalis xanthomelas (Esper, [1781]) (Nymphalidae: Nymphalinae). A total of nine specimens were collected during 2012–2013 (Table 1). During many decades (at least since the 1970s), the species was rare in Arkhangelsk Region and only a few accidental migrants were recorded there. However, mass expansions of the species to the North were registered in 2012–2013. I.N. Bolotov recorded two overwintered specimens in Arkhangelsk city (64°31′51″ N, 040°37′35″ E, ca. 200 km northward from Uyta village) on 20 April 2014, that demonstrates their successful hibernation at 64°32′ N.

Lycaena dispar (Haworth, 1802) (Lycaenidae: Lycaeninae). Material examined: 1 specimen, 21 July 2012, site no. 3, leg. I.A. Bochneva; 1 specimen, 8 July 2013, site no. 1, leg. I.A. Bochneva. (Figure 6). First documented species record from Arkhangelsk Region. According to some authors (Saarinen and Jantunen 2013), the species' abundance has recently increased in Finland, contemporaneously with the fast expansion of its range in that country. Gorbach (2013) documented a recent range expansion of the species in Karelia Republic.

Lycaena helle ([Denis & Schiffermüller], 1775) (Lycaenidae: Lycaeninae). Material examined: 1 specimen, 16 June 2012, site no. 3, leg. I.A. Bochneva. In Arkhangelsk Region, the species was registered as common for some localities, especially in tall-herb forest meadows in river and stream valleys on the White Sea-Kuloi Plateau. The species is rare in Karelia Republic (Gorbach 2013), but relatively common in Komi Republic (Tatarinov and Dolgin 1999; Tatarinov 2013).

Lycaena phlaeas (Linnaeus, 1761) (Lycaenidae: Lycaeninae). Material examined: 1 specimen, 12 August 2012, site no. 2, leg. I.A. Bochneva. It is a first recent record from Arkhangelsk Region. The species is rare in Karelia Republic (Gorbach 2013) and Komi Republic, excluding the Ural Mountain Range, where it is relatively common (Tatarinov and Dolgin 1999; Tatarinov 2013).

Cupido alcetas (Hoffmannsegg, 1804) (Lycaenidae: Polyommatinae). Material examined: 2 specimens, 21 July 2012, site no. 2 and no. 3, leg. I.A. Bochneva. It is a second reliable record from Arkhangelsk Region since 1978 (Tikhomirov and Bolotov 2000; Bolotov 2004). The species is not recorded in Karelia Republic (Gorbach 2013) and is rare in Komi Republic (Tatarinov and Dolgin 1999; Tatarinov 2013).

Cupido minimus (Fuessly, 1775) (Lycaenidae: Polyommatinae). Material examined: 1 specimen, 10 June 2012, site no. 1, leg. I.A. Bochneva. It is a second reliable record from Arkhangelsk Region since 1978 (Tikhomirov and Bolotov 2000; Bolotov 2004). The species is rare in Karelia Republic (Gorbach 2013) and Komi Republic, excluding the Ural Mountain Range, where it is relatively common (Tatarinov and Dolgin 1999; Tatarinov 2013).

ACKNOWLEDGEMENTS

This study was partially supported by grants of the President of Russia (project no. MD-6465.2014.5), the Ural Branch of the Russian Academy of Sciences (projects nos. 15-12-5-3 and 15-2-5-7) and the authorities of the Arkhangelsk Region (Young Scholar Scientific Program, project no. 11-2015-03a).

LITERATURE CITED

Bergman, K. O., J. Askling, O. Ekberg, H. Ignell, H. Wahlman, P. Milberg. 2004. Landscape effects on butterfly assemblages in an agricultural region. Ecography 27 (5): 619–628. doi: 10.1111/j.0906-7590.2004.03906.x

Bolotov, I.N. 2002. Butterflies (Lepidoptera, Rhopalocera) of Arkhangelsk city and its vicinities. Zoologicheskii Zhurnal 81 (4): 457–462. [In Russian].

Bolotov, I.N. 2004. Long-term changes in the fauna of diurnal Lepidopterans (Lepidoptera, Diurna) in the Northern Taiga Subzone of the Western Russian Plain. Russian Journal of Ecology 35 (2): 117–123. doi: 10.1023/B:RUSE.0000018937.44836.c6

Bolotov, I.N. 2006. Diurnal butterflies (Lepidoptera, Rhopalocera) of the Solovetskie Islands (Northwestern Russia, the White Sea). Entomological Review 86 (5): 516–523.

Bolotov, I.N. 2012. The fauna and ecology of butterflies (Lepidoptera, Rhopalocera) of the Kanin Peninsula and Kolguev Island. Entomological Review 92 (3): 296–304. doi: 10.1134/S0013873812030062

Bolotov, I.N. and E.V. Shutova. 2006. Patterns of formation of island fauna of butterflies (Lepidoptera, Diurna) at the Northern Forest Boundary in the region of Pleistocene continental glaciation (by the example of White Sea Islands). Biology Bulletin 3: 327–336. doi: 10.1134/S1062359006030083

Bolotov, I.N., M.V. Podbolotskaya, Yu.S. Kolosova, and N.A. Zubrii. 2013. The current flow of migrants and its contribution to butterfly faunas (Lepidoptera, Rhopalocera) on marine islands with young allochthonous biota. Biology Bulletin 40 (1): 78–88. doi: 10.1134/S1062359012060040

Bolotov, I.N., M.Y. Gofarov, A.M. Rykov, A.A. Frolov and Y.I. Kogut. 2013a. Northern boundary of the range of the Clouded Apollo butterfly *Parnassius mnemosyne* (L.) (Papilionidae): climate influence or degradation of larval host plants? Nota Lepidopterologica 36 (1): 19–33. http://www.soceurlep.eu/tl_files/nota/bd36_1/03_Bolotov.pdf

Bol'shakov, L.V., A.G. Tatarinov, O.I. Kulakova and I.N. Bolotov. 2008. The northernmost localities of species in the genus *Leptidea* Billberg, 1820 (Lepidoptera, Pieridae) in Arkhangelsk region. Eversmannia 15–16: 90–91. [In Russian].

Colwell, R. K. 2013. EstimateS: Statistical estimation of species richness and shared species from samples. Version 9.1.0. User's Guide and application. Accessed at http://purl.oclc.org/estimates, 9 May 2014.

Gorbach, V.V. 2013. Fauna and ecology of butterflies (Lepidoptera: Hesperioidea et Papilionoidea) of Karelia. Petrozavodsk: Petrozavodsk State University Press. 254 pp. [In Russian].

Gorbach, V. V. and K. Saarinen. 2003. The butterfly assemblages of Onega Lake Area in Karelia, middle taiga of NW Russia (Hesperioidea, Papilionoidea). Nota Lepidopterologica 25 (4): 267–279.

Harris, I., P.D. Jones, T.J. Osborn, and D.H. Lister. 2014. Updated high-resolution grids of monthly climatic observations — the CRU TS3.10 dataset. International Journal of Climatology 34(3): 623–642. doi: 10.1002/joc.3711

Heliölä, J., M. Kuussaari and I. Niininen. 2012. Maatalousympäristön päiväperhosseurannan vuoden 2011 tulokset [Results of the butterfly monitoring scheme in Finnish agricultural landscapes for the year 2011]. Baptria 37 (1): 24–31. [In Finnish].

Krulikovsky, L.K. 1909. An information on the Lepidoptera fauna of the Vologda Gubernia. Russian Entomological Review 1–2: 65–69. [In Russian].

Kudrna, O., A. Harpke, K. Lux., J. Pennerstorfer, O. Schweiger, J. Settele and M. Wiemers. 2011. Distribution atlas of butterflies in the Europe. Halle, Germany: Gesellschaft fur Schmetterlingschutz. 576 pp.

Kuussaari, M., J. Pöyry, and K.-E. Lundsten. 2000. Maatalousympäristön päiväperhosseuranta: surantame-netelmä ja ensimmäisen vuoden tulokset [Butterfly monitoring in agricultural landscapes: the method and first's year results]. Baptria 25 (2): 44–56. [In Finnish].

Kuussaari, M., J. Heliölä and I. Niininen. 2001. Maatalousympäristön päiväperhosseurannan vuoden 2001 tulokset [Results of the butterfly monitoring scheme in Finnish agricultural landscapes for the year 2001]. Baptria 26 (2): 69–80. [In Finnish].

Marttila, O., K. Saarinen and T. Lanthi. 2001. Valtakunnallinen päiväperhosseuranta — Ensimmäisen 10-vuotisjakson (1991–2000) tulokset [The National Butterfly Recording Scheme in Finland (NAFI) – Results of the first ten years (1991–2000)]. Baptria 26 (2): 29–65. [In Finnish].

Mikkola, K. 2003a. The Red Admiral butterfly (*Vanessa atalanta*, Lepidoptera: Nymphalidae) is a true seasonal migrant: an evolutionary puzzle resolved? European Journal of Entomology 100: 625–626. http://www.eje.cz/pdfs/eje/2003/04/23.pdf

Mikkola, K. 2003b. Red Admirals *Vanessa atalanta* (Lepidoptera: Nymphalidae) select northern winds on southward migration. Entomologica Fennica 14: 15–24.

Parmesan, C., N. Ryrholm, C. Stefanescu, J. K. Hill, C. D. Thomas, H. Descimon, B. Huntley, L. Kaila, J. Kullberg, T. Tammaru, W. J. Tennet, J. A. Thomas and M. Warren. 1999. Poleward shifts in geographical ranges of butterfly species associated with regional warming. Nature 399: 579–583. doi: 10.1038/21181

Saarinen, K. 2010. Seurannassa täyteen 20 vuotta — Päiväperhoset ovat matkalla pohjoiseen [Monitoring of the full 20 years — Butterflies are in a way to the North]. Baptria 35: 111. [In Finnish].

Saarinen, K. and J. Jantunen. 2013. Päiväperhoset matkalla pohjoiseen [Butterflies are heading to the North]. Helsinki: Hyönteistarvike Tibiale Oy. 247 pp. [In Finnish].

Stefanescu, C. 2001. The nature of migration in the red admiral butterfly *Vanessa atalanta*: evidence from the population ecology in its southern range. Ecological Entomology 26: 525–536. doi: 10.1046/j.1365-2311.2001.00347.x

Stefanescu, C, M. Alarcón and A. Àvila. 2007. Migration of the painted lady butterfly, *Vanessa cardui*, to north-eastern Spain is aided by African wind currents. Journal of Animal Ecology 76(5): 888–898. doi: 10.1111/j.1365-2656.2007.01262.x

Stefanescu, C., F. Páramo, S. Åkesson, M. Alarcón, A. Ávila, T. Brereton, J. Carnicer, L. Cassar, R. Fox, J. Heliölä, J. K. Hill, N. Hirneisen, N. Kjellén, E. Kühn, M. Kuussaari, M. Leskinen, F. Liechti, M. Musche, E. Regan, D. Reynolds, D. B. Roy, N. Ryrholm, H. Schmaljohann, J. Settele, C. D. Thomas, C. van Swaay and J. Chapman. 2012. Multi-generational long-distance migration

in insects: studying the painted lady butterfly in the Western Palaearctic. Ecography 36(4): 474–486. doi: 10.1111/j.1600-0587.2012.07738.x

Tatarinov, A.G. 2013. Landscape-zonal distribution of butterflies (Lepidoptera, Papilionoidea, Hesperioidea) in the northeast of the Russian Plain. Entomological Review 93 (1): 56–68. doi: 10.1134/S0013873813010090

Tatarinov, A. G. and M. M. Dolgin. 1999. Butterflies. Fauna of the European north-east of Russia series, vol. 7, part 1. St. Petersburg: Nauka. 183 pp. [In Russian].

Tikhomirov, A.M. and I.N. Bolotov. 2000. Fauna of butterflies (Lepidoptera, Rhopalocera) of the Pinega Reserve and adjacent territories; pp. 334–342, in: F.N. Yudakhin (ed.). Northern regions. Ecology. Yekaterinburg: Ural Branch of RAS Publ. [In Russian].

Warren, M. S., J. K. Hill, J. A. Thomas, J. Asher, R. Fox, B. Huntley, D. B. Roy, M. G. Telfer, S. Jeffcoate, P. Harding, G. Jeffcoate, S. G. Willis, J. N. Greatorex-Davies, D. Moss and C. D. Thomas. 2001. Rapid responses of British butterflies to opposing forces of climate and habitat change. Nature 414: 65–69. doi: 10.1038/35102054

Authors' contribution statement: INB identified specimens, provided calculations and wrote the text, IAB collected the data, MVP wrote the text as co-author, MYG worked on the maps, VMS photographed specimens.

Received: 11 August 2014
Accepted: 23 August 2015
Academic editor: Cristiano Iserhard

Appendix 1

Phenology plots for common butterfly species of Vinogradovsky District, Arkhangelsk Region, Northern European Russia (summarized data of 62 samples collected in period 2011–2013 from three meadow sites). N – number of specimens of the butterfly species in the general sample.